Chapter 10
The "Structural Disaster" of the Science-Technology-Society Interface

From a Comparative Perspective with a Prewar Accident

Miwao Matsumoto

Abstract This chapter attempts to shed fresh light on the structural causes of the Fukushima accident by illuminating the patterns of behavior of the agents involved in a little-known but serious accident that occurred immediately before World War II. Despite the expected incalculable damages caused by the Fukushima Daiichi nuclear power plant accident, critical information was restricted to government insiders. This state of affairs reminds us of the state of prewar Japanese wartime mobilization in which all information was controlled under the name of supreme governmental authority. This paper argues that we can take the comparison more seriously as far as the patterns of behavior of the agents involved are concerned. The key concept that is employed for that argument is the "structural disaster" of the science-technology-society interface, the causes of which can be divided into two different categories, organizational errors and technological trajectory. Through the lens of "structural disaster", the possibility of functional disintegration coupled with structural interdependence and secrecy is drawn for investigation relevant both in wartime and in peacetime. This paper will contextualize the sociological implications of the possibility for all of us who face the post-Fukushima situation based on exploration into the hidden prewar accident with particular focus on a subtle relationship between success and failure.

Keywords Structural disaster · Secrecy · Fukushima · Wartime mobilization · Science-technology-society interface

M. Matsumoto (✉)
Department of Sociology, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
e-mail: miwao@L.u-tokyo.ac.jp

J. Ahn et al. (eds.), *Reflections on the Fukushima Daiichi Nuclear Accident*,
DOI 10.1007/978-3-319-12090-4_10

10.1 Introduction

The Fukushima Daiichi nuclear power plant accident was extremely shocking, but what is even more shocking in the eyes of the present writer is the devastating failure in transmitting critical information on the accident to the people when the Japanese government faced unexpected and serious events after March 11, 2011. Secrecy toward outsiders seems to have caused this failure: secrecy to the people who were forced to evacuate from their birthplaces, to the people who wanted to evacuate their children, to the people who have been suffering from tremendous opportunity loss such as giving up entering college, and others. It is virtually impossible to enumerate individual instances of suffering and aggregate them in an ordinarily calculable manner. Despite such expected incalculable damage, critical information was restricted to government insiders. This state of affairs seems to show similar tendencies to the state of prewar Japanese mobilization in which all information was controlled under the name of supreme governmental authority [1].

One might consider such a comparison to be merely rhetorical. This chapter argues that we can take the comparison more seriously as far as the patterns of behavior of the agents involved are concerned. It is true that the prewar Japanese military regime was oriented toward mobilization for war while the postwar regime has been prohibited from mobilization for war purposes of any kind by the constitution. In this respect there is a large discrepancy between the prewar and postwar regimes as to their purpose. However, the surprising but telling similarity of the patterns of behavior embedded in the regimes is evident if we look into the details of a hidden accident that took place just before the outbreak of World War II (abbreviated to WWII hereafter).

This chapter attempts to shed fresh light on the structural causes of the Fukushima Daiichi accident by illuminating the patterns of behavior of the agents involved in the little-known but serious accident involving naval vessels that occurred immediately before WWII with a particular focus on the subtle relationship between success and failure in the complex science-technology-society interface. The chapter will then contextualize the similarity and draw its sociological implications for all of us who face the post-Fukushima situation. The conceptual tool that is employed here to that end is the "structural disaster" of the science-technology-society interface.

10.2 The "Structural Disaster" of the Science-Technology-Society Interface

The "structural disaster" of the science-technology-society interface is the concept developed to give a sociological account of the repeated occurrence of failures of a similar type [2]. In particular, it is developed to clarify a situation where novel and undesirable events happen but there is no single agent to blame and no place to allocate responsibility for the events and to prescribe remedies. The reason for denominating this failure as the failure of the science-technology-society interface rather than that of science, or of technology, or of society is worthy of attention to understand the development of my argument. For example, if nuclear physics is completely successful in understanding a chain reaction, technology such as nuclear engineering could fail in controlling the reaction as in the case of Chernobyl.[1] Or if nuclear engineering is almost completely successful in containing radioactive materials within reactors, social decision-making could fail as in the case of Three Mile Island (TMI).[2] Or if society is completely successful in setting goals for the development of renewable energy technologies, science and/or technology could fail as in the case of Ocean Thermal Energy Conversion (OTEC).[3]

In a word, the success or failure of science, of technology, and of society cannot be overlapped automatically [9, 10]. In particular, there seems to be something missing in-between, which has unique characteristics of its own. The concept of "structural disaster" is intended to explore this state. What is in-between could be institutional arrangements, organizational routines, tacit interpretations of a formal code of ethics, invisible customs, or the networks of interests of different organizations. The "structural disaster" consists of one or more of the following elements [11]:

1. Adherence to erroneous precedents causes problems to be carried over and reproduced.
2. The complexity of a system under consideration and the interdependence of its units aggravate problems.
3. The invisible norms of informal groups essentially hollow out formal norms.
4. Quick fixes for problems at hand lead to further such fixes for temporary counter measures.
5. Secrecy develops across different sectors and blurs the locus of agents responsible for the problems to be addressed.

This chapter focuses on, among other things, the interdependence of heterogeneous agents, which come into play in the science-technology-society interface and give rise to secrecy in a specific social condition. This chapter will make clear the interdependence by tracing it back to the hidden prewar accident, which will give us an important clue to the understanding of the Fukushima Daiichi accident from the perspective of "structural disaster" as defined above. To understand the social context of this hidden prewar accident, it is necessary to move away from the current social condition of the post-Fukushima situation to the prewar wartime mobilization of science and technology, within which the clarification of this hidden accident can be properly pursued. After the clarification, we will move back to the current situation surrounding the Fukushima Daiichi accident, to present the sociological implications of the hidden accident for the Fukushima Daiichi accident and for potential future extreme events.

---

[1] For a sociological investigation into the relationships between the Chernobyl and Wind scale incident, see [3]. For a different view on the relationships, see [4].

[2] For a pioneering sociological investigation into TMI, see [5]. Also see [6, 7].

[3] On a sociological account of an unanticipated social consequence of OTEC, see [8].

10.3 The Basic Points About the Fukushima Daiichi Accident from the Perspective of "Structural Disaster"

To elucidate the problem of secrecy in the Fukushima Daiichi accident, several basic points can be noted from the perspective of "structural disaster," which should be kept in mind in approaching the hidden accident that happened much earlier than the Fukushima Daiichi accident. First, there seems to have arisen a repeated occurrence of similar patterns of behavior that have run through various different instances and in the end have given rise to secrecy. It is true that the emergency situation during and after such an extreme event as the Fukushima Daiichi accident can provide a good reason to expect confusion and delay in transmitting information. But the degree and range of confusion and delay went far beyond those to be expected from an emergency situation alone.

For example, the System for Prediction of Environmental Emergency Dose Information (abbreviated to SPEEDI hereafter) was developed with the assistance of more than ten billion yen to make the early evacuation of the people affected smoother and safer. The first recommendation from the Japanese government for evacuation was made on March 12. The prediction obtained from SPEEDI was made public for the first time on April 26, despite the fact that its prediction had been made shortly after the accident. As a result of this secrecy, the affected residents were advised by the government to evacuate without reliable information at the critical initial phase when they were exposed to a high level dose. All they could do was to trust the government or not. SPEEDI had been awarded the first nuclear history award by the Atomic Energy Society of Japan in 2009 [12], but its prediction was never made public when it was needed.

A similar behavior pattern of the government and the resulting secrecy and serious suffering can be observed in various other cases in the accident, such as the delayed venting of the nuclear reactors in the Fukushima Daiichi nuclear power station, the deregulation for recycling decontaminated mud for concrete production, and the rise and fall of dose levels allowed for children in primary school and for workers in the station. In light of structural causes implied in the "structural disaster", organizational errors seem to have intervened behind this state of affairs: TEPCO's disobedience of the directive by the prime minister, the malfunction of the so-called "double check" system within Ministry of Economy, Trade and Industry (METI), miscommunication between nuclear engineers of the makers of the reactors and TEPCO officials, and others. If we look into the details of the Fukushima Daiichi accident as embodying "structural disaster," organizational errors of this kind should be scrutinized, elaborated on, and extended as one of the crucial causes of "structural disaster." This is the first point to be noted in approaching the hidden accident that happened much earlier than the Fukushima Daiichi accident and in obtaining a broader perspective.

Second, we need to carefully place the specifications of six nuclear reactors at the Fukushima Daiichi power station in a technological trajectory, within which

Table 10.1 Specifications of the nuclear reactors at the Fukushima Daiichi power station

Reactor unit no.	1	2	3	4	5	6
Type	BWR	BWR	BWR	BWR	BWR	BWR
Container vessel	Mark I	Mark I	Mark I	Mark I	Mark I	Mark II
Output ($\times 10^4$ kW)	46	78.4	78.4	78.4	78.4	110
Makers	GE	GE/Toshiba	Toshiba	Hitachi	Toshiba	GE/Toshiba
Domestics (%)	56	53	91	91	93	63
Year Built	1971	1974	1976	1978	1978	1979

Source [13]

we might be able to properly understand what “structural disaster” implies (see Table 10.1).

There are two reasons for paying attention to the technological trajectory to understand the Fukushima Daiichi accident as “structural disaster.” First, every reactor there had a long history of successful operation extending over 30 years since its start in the 1970s, which forces our attention to turn to the possibility of a more “structural” cause of the accident beyond picking up individual ad hoc troubles and errors. Second, as the ratios of domestic production indicate, the reactors at the Fukushima Daiichi power station embody the turning point leading from licensed production to self-reliant production. For these reasons, there could exist common characteristics throughout the reactors in question at the Fukushima Daiichi power station and it is possible that such characteristics are somehow related to the “structural disaster” of the science-technology-society interface as manifested in the accident.

In a word, the causes of “structural disaster” can be divided into two different categories, organizational errors and technological trajectory, as the first step to explaining the Fukushima Daiichi accident.[4] If we can substantiate these two elements in understanding other independent cases as “structural disaster,” then we will be able to have a stronger position to learn lessons from the Fukushima Daiichi accident as a “structural disaster” and to extend their implications for potential future extreme events. What follows is an independent substantiation of these two elements by examining the hidden accident happened long before the Fukushima Daiichi accident with a focus on a complex relationship between success and failure in the science-technology-society interface and secrecy in the interface.

The hidden accident long before the Fukushima Daiichi one is a very perplexing accident of the naval turbine developed by the Imperial Japanese Navy, which occurred immediately before the outbreak of WWII. This accident enables us to redefine the complex relationship between success and failure in the science-technology-society interface both in peacetime and wartime. The accident was treated as top secret because of its timing. The suppression of information about the accident means that it has not been seriously considered as an event in the sociology of science and technology up to now. However, the description and

[4] On organizational errors in the context of technological failures, see [14–17] regarding the Fukushima Daiichi accident. For a pioneering study referring to the dynamic aspect of technological trajectory in the history of technological change, see [18].

analysis of this accident will suggest that technological development can depart significantly from a unidirectional process. This also implies that we need to revise our view of the science-technology-society interface beyond a simplistic dichotomous understanding in terms of success or failure.

The steam turbine was invented, and finally patented in 1884, by British engineer C.A. Parsons, who in 1894 obtained a patent for the marine turbine [19].[5] After Parsons' original invention, it was supposed that the marine turbine had become a reliable, mature technology in the prewar period. The hidden accident of the naval turbine that occurred immediately before WWII, however, throws doubt on the validity of a unidirectional and one-dimensional view of such a development trajectory for technology. To confirm this doubt, it is necessary to outline the development trajectory of the Japanese type naval turbine by making clear the locus of the complex relationship between success and failure.

10.4 The Development Trajectory of the Kanpon Type and Its Pitfalls

The technology taken up here is the Kanpon type turbine, Kanpon being the Technical Headquarters of the Navy. The Kanpon type turbine was developed by the Imperial Japanese Navy about 1920 to substitute entirely self-reliant technologies for imported ones. This naval turbine provides the key to understanding the connection between success and failure. The reason is that the Kanpon type was the standard turbine for Japanese naval vessels from 1920 to 1945, and as regards its blades a serious but almost inexplicable and little-known accident occurred immediately before WWII.[6] The first question to approach the core of the connection between success and failure lies in the background against which the Kanpon type turbine was developed.[7]

From the time of the first adoption of the marine turbine in the early twentieth century (1905) after intensive investigations and license contracts, the Imperial Japanese Navy accumulated experience in the domestic production of marine turbines. Throughout this process, the Navy carefully monitored the quality of British, American, and various other Western type turbines and evaluated them.[8]

5 As for the procession of events before 1884, see [20].

6 Kanpon is the abbreviation of the Kansei Honbu, which means the Technical Headquarters of the Imperial Japanese Navy.

7 Studies on the innate connection between success and failure of the science-technology-society interface have scarcely been undertaken from the sociological point of view. See [21] for a shortened version of this chapter.

8 The British type originated in Parsons and the American type in Curtis turbines, respectively. The first demonstration of the Parsons turbine at the Naval Review in 1897 caused a sensation [22]. With respect to the Curtis turbine, see [23]. On detailed descriptions and analyses of these dual strategies of the Navy outlined here, see [24, pp. 54–63]. As for a more general background of the relation between the Navy and private companies, see [24, pp. 74–78].

Table 10.2 Synopsis of geared turbine failures of naval vessels from 1918

Date	Ship name	Ship type	Specification	Turbine type
3 Oct 1918	Tanikaze	Destroyer	Blade fell out	Brown-Curtis
30 Nov 1918	Minekaze	Destroyer	All blades fell out	Brown-Curtis (HP) Parsons (LP)
26 Feb 1919	Sawakaze	Destroyer	Blade sheared and dropped off	Brown-Curtis (HP)
30 Apr 1919	Tenryu	Cruiser	Blade sheared	Brown-Curtis
21 Nov 1919	Tatsuta	Cruiser	Blade smashed	Brown-Curtis
6 Feb 1920	Nire	Destroyer	Blade sheared	Brown-Curtis (HP) Parsons (LP)
Apr 1920	Kawakaze	Destroyer	Blade sheared	Brown-Curtis
28 Sep 1920	Shimakaze	Destroyer	Blade breakage	Brown-Curtis (HP) Parsons (LP)
20 Dec 1920	Kuma	Cruiser	Blade breakage	Gihon
18 Mar 1922	Sumire	Destroyer	Blade damaged	Zölly

Source [25, 26]. The same naval vessels and naval vessels of the same class suffered similar failures and breakdowns many times. These repeat failures and breakdowns are omitted here. The secondary failures and breakdowns caused by the initial ones are also omitted altogether. Gihon in the table is the multiple-flow turbine designed by the predecessor of the Technical Headquarters of the Navy. Geared turbines made possible an increase of one order of magnitude in revolutions per minute, from 100–200 to 1,000–2,000, which might have affected turbines designed for 100–200 rpm.

As a result, a reduction gearing adopted by the Navy for the first time in 1918 contributed greatly to the total efficiency of the main turbines.

However, quite unexpectedly, the introduction of reduction gearing caused one failure after another from 1918 (see Table 10.2).

What was most important to the Navy was the fact that all the geared turbines causing failures and breakdowns were Western types as shown in Table 10.2. And the license contracts with the makers of the two leading turbines, the Curtis and the Parsons types, were due to expire in June 1923 and in August 1928, respectively. Considering the failures and breakdowns in light of this situation, the Navy started to take official steps to develop its own type.[9] For the purpose of replacing imported turbines, the new Kanpon type turbine was developed, and achieved standardization in design, materials, and production method "that is independent of foreign patents" ([26, pp. 133–134]. The Kanpon type turbine was also expected to achieve cost reduction and flexible usage for a wide range of purposes, which would be made possible by standardization.

Thus the Kanpon type turbine was developed and established as the standard turbine for Japanese naval vessels due to the failures and breakdowns of imported

9 In February 1921, a turbine conference was organized by the director of the Military Affairs Bureau of the Navy to drastically reconsider the design, production method, materials, and operation method of geared turbines. As a result, the configurations, materials, strength, and installation of turbine blades were all improved. In addition, in August 1922, the Yokosuka arsenal of the Navy undertook an experiment on the critical speed of turbine rotors in accordance with the Military Secret No. 1148 directive in order to determine the normal tolerance of turbine rotors in terms of revolutions per minute. The above descriptions are based on [26, 27].

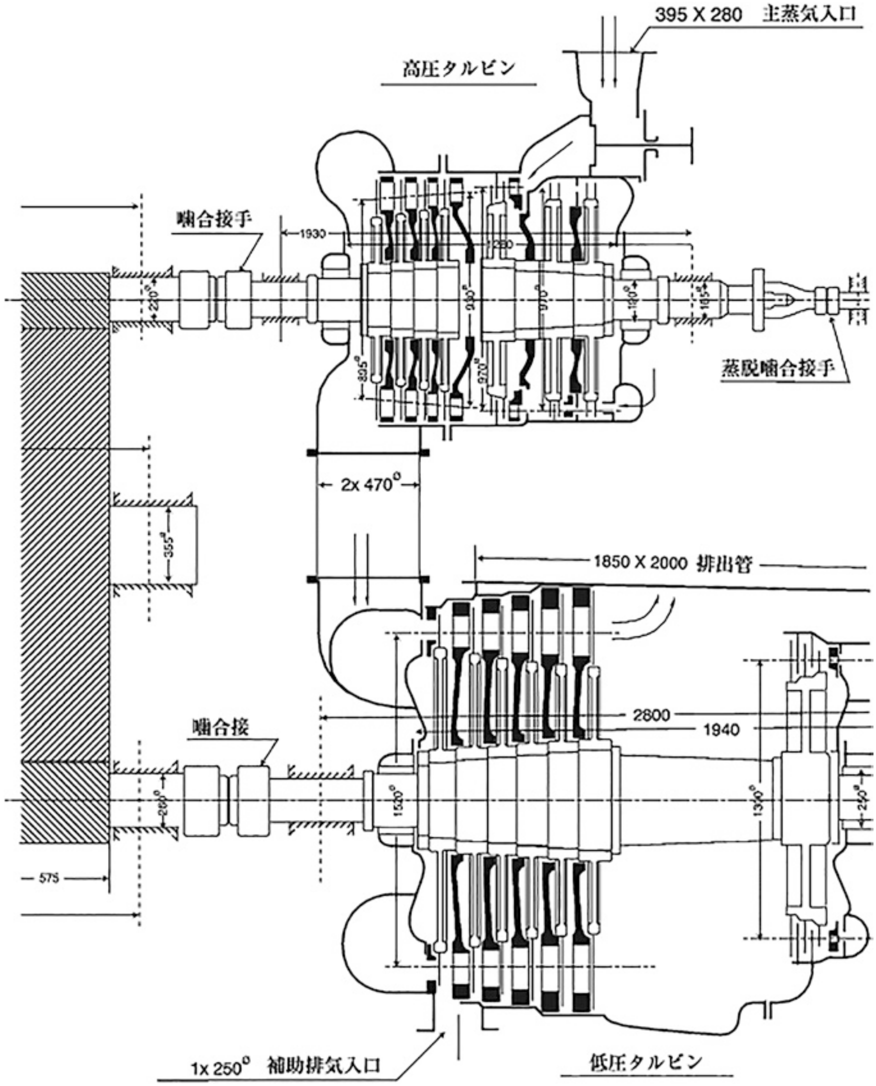


Fig. 10.1 Plane view of the first Kanpon type turbine (*Source* [28])

turbines experienced by the Navy. The first Kanpon type turbine was installed in destroyers built in 1924 (see Fig. 10.1).[10]

All Japanese naval vessels continued to adopt this Kanpon type turbine until 1945. Everyone regarded it as a landmark that showed the beginning of adoption of self-reliant technologies. This is because, as the Shipbuilding Society of Japan wrote in its official history of naval architecture and marine engineering, "there

[10] For the detail of this first Kanpon type turbine, see [24], Chap. 3. Also see [28].

had been no serious trouble with the turbine for more than ten years since the early 1920s, and the Navy continued to have strong confidence in their reliability." [29, Vol. 1, p. 668].

What follows is an important counterargument to this account, by calling attention to the missing failure linking success and failure, a pitfall inherent in the trajectory. The detailed description and analysis of the hidden but serious incident of the established Kanpon type turbine that occurred immediately before WWII will show how important and meaningful this pitfall is for the trajectory of Japan's technological development, its organizational errors, and its science-technology-society interface. This is particularly because, as will be clarified below, the pitfall was profoundly related to the functional disintegration of the military-industrial-university complex caused by an unbalanced secrecy, one of the key factors leading to "structural disaster." The military-industrial-university complex hereafter means an institutional structure made up of the governmental sector, particularly the military, the private industrial sector, and universities—mutually autonomous in their behavior but in combination expected to contribute to national goals.[11]

10.5 The Accident Kept Secret

In December 1937, a newly built destroyer encountered an unexpected turbine blade breakage accident. Since the accident involved the engine of standard design, it caused great alarm. A special examination committee was set up in January 1938 to investigate the accident. The committee was called Rinkichō in Japanese. This chapter will refer to the accident as the Rinkichō accident hereafter. Today, there are five non in-house books containing references to the Rinkichō accident. The first reference to the accident appeared in 1952, and the last in 1981.[12] The publication dates and the authors/editors of the references are all

[11] See [24, p. 50]. There is no implication herewith that the complex was designed in Japan by the "rich nation, strong army" policy in a top-down manner. Rather the complex in Japan had an endogenous origin. See [24], Chap. 3. As for the "rich nation, string army" policy, see [30]. The endogenous origin of the complex might also be detected in Britain as shown by the connection between physics and engineering in the life of Lord Kelvin. See [31]. For a study on the complex with reference to American science and technology, see [32].

[12] In 1952, seven years after WWII ended, the first reference appeared in [33] compiled under the leadership of Michizō Sendō who was an engineering Rear Admiral of the Navy. Four years later, the second reference appeared in [34] written by Masanori Itō who was a Mainichi newspaper reporter and was also a graduate of the Naval Academy. The third reference [35] that appeared in 1969 gives the most authentic history of the failure among the five books. Eight years later, in 1977, the fourth reference appeared in [29]. The editor-in-chief was a former engineering officer of the Navy, and the editorial committee of the society also included several other engineering officers of the Navy. Of the five books, this reference provides the most detailed description of the technical aspects of the failure, which will be examined below based on newly discovered primary source materials. In 1981, the last reference [36] appeared in *Kaigun* (The Navy) compiled by the Institute for the Compilation of Historical Records relating to the Imperial Japanese Navy.

Table 10.3 References to the Rinkichō accident

Year of reference	Author/Editor
1952	Former engineering rear admiral of the navy
1956	Mainichi newspaper reporter (Graduate of the Naval Academy)
1969	War history unit of the national defense college of the defense agency
1977	Japan shipbuilding society (editor-in-chief and several members of the Editorial committee were former technical officers of the navy)
1981	Institute for historical record compilation on the navy

different, but all were written by parties connected with the Imperial Japanese Navy (see Table 10.3).

The accounts given in these references agree for the most part on their main points that the cause was soon identified, resulting in no serious consequence. These references make up a kind of success story. And it is extremely difficult to look into further details of the failure because little evidence is provided to prove what is stated by these references. It appears that the accident was kept secret because it occurred during wartime mobilization.

To confirm this, an examination of government documents from around the time of the accident is in order. The government documents consulted here are the minutes of Imperial Diet sessions regarding the Navy. The minutes of the 57th Imperial Diet session (held in January 1930) to the 75th Imperial Diet session (held in March 1940) contain no less than 7,000 pages about Navy-related discussions. These discussions include ten naval vessel incidents summarized in Table 10.4.

It is noteworthy in these discussions that the Fourth Squadron incident of September 1935, one of the most serious incidents in the history of the Imperial Japanese Navy, was made public and discussed in the Imperial Diet sessions within a year (on May 18, 1936).[13] The Rinkichō accident occurred on December 29, 1937, and was handed down informally within the Navy and counted as a major incident on a par with the Fourth Squadron incident.[14]

However, more than two years after the Rinkichō accident there is no sign in the documents that it was made public and discussed in Imperial Diet sessions. As will be noted in detail, reports on the accident had already been submitted during the period from March to November 1938 (the final report was submitted on November 2). Nevertheless the Imperial Diet heard nothing about the accident or any detail of measures taken to deal with it. The Rinkichō accident was so serious that it would have influenced the decision on whether to go to war with the U.S.

[13] The *Tomozuru* incident of March 11, 1934 was the first major one for the Imperial Japanese Navy. Only one year and a half after this, a more serious incident occurred on September 26, 1935—the Fourth Squadron incident.

[14] Based on interviews by the present writer with Dr. Seikan Ishigai (on September 4, 1987; June 2, 1993) and with Dr. Yasuo Takeda (on September 25, 1996; March 19, 1997).

Table 10.4 Discussions in the imperial diet regarding naval vessel accidents, etc.: January 1930–March 1940

Date	Description
February 13, 1931	Questions about the cause of the collision between the cruiser *Abukuma* and *Kitakami*. (Shinya Uchida's questions were answered by the Minister of the Navy, Abo, at the Lower House Budget Committee, the 59th Imperial Diet session)
March 2, 1931	Questions about the measures taken before and after the collision between the cruiser *Abukuma* and *Kitakami* during large-scale maneuvers in 1930 and the responsibility of the authorities. (Tanetada Tachibana's questions were answered by the Minister of the Navy, Abo, at the House of Lords Budget Committee, the 59th Imperial Diet session)
March 17, 1933	Questions about the Minister of the Navy's view on the expenditure (12,000 yen) on repairs to the destroyer *Usugumo* and on the fact that the destroyer struck a well-known submerged rock. (Shinya Uchida's questions were answered by the Minister of the Navy, Ōsumi, at the Lower House Budget Committee, the 64th Imperial Diet session)
March 2, 1935	Request for information about the results of investigation into a scraping incident involving four destroyers, apparently on training duty in Ariake Bay, reported in newspapers. (Yoshitarō Takahashi's questions were answered by the Minister of the Navy, Ōsumi, at the Lower House Budget Committee, the 67th Imperial Diet session)
May 18, 1936	Request for information about the seriousness of the collision between submarines I-53 and I-63 and the amount of money drawn from the reserve as a remedy. (Kanjirō Fukuda's questions were answered by the Accounting Bureau Director, Murakami, at the Lower House plenary session, the 69th Imperial Diet session)
May 18, 1936	Request for detailed information about the degree of damage to two destroyers due to violent waves in September 1935. (Kanjirō Fukuda's questions were answered by the Accounting Bureau Director, Murakami, at the Lower House plenary session, the 69th Imperial Diet session)
February 6, 1939	Brief explanation of the accident of submarine I-63. (The Minister of the Navy, Yonai, explained at the House of Lords plenary session, the 74th Imperial Diet session)
February 7, 1939	Brief explanation of the accident of submarine I-63. (The Minister of the Navy, Yonai, explained at the Lower House plenary session, the 74th Imperial Diet session)
February 25, 1939	Request for a brief explanation of the sinking of a submarine due to collision during maneuvers. (Takeo Kikuchi's questions were answered by the Director of the Bureau of Military Affairs, Inoue, at the House of Lords Budget Committee, the 74th Imperial Diet session)
February 1, 1940	Brief report on the completion of the salvage of the sunken submarine I-63. (The Minister of the Navy, Yoshida, reported at the House of Lords plenary session, the 75th Imperial Diet session)

and Britain. The Fourth Squadron incident was also serious enough to influence the decision in that it dramatically disclosed the inadequate strength and stability of the hull of the standard naval vessels designed after the London naval disarmament treaty concluded in 1930.[15] But it was made public and discussed in Imperial Diet sessions. In this respect, there is a marked difference between the handling of the two incidents. Regarding the Fourth Squadron incident, the Director of the Naval Accounting Bureau, Harukazu Murakami, was forced to give an answer to a question by Kanjirō Fukuda (Democratic Party) at the 69th Imperial Diet session held on May 18, 1936.[16]

Although his answer gave no information regarding the damage to human resources (all members of the crew confined within the bows of the destroyers died), it accurately stated the facts of the incident and the material damage incurred, which amounted to 2.8 million yen in total. Even the damage due to the collision between cruisers about five years earlier in Table 10.4 was only 180,000 yen. The answer from a naval official clearly attested that the Fourth Squadron incident was so extraordinarily serious as to oblige him to disclose this fact to the public.[17] It should be noted here that remedial measures for the problem of the turbines of all naval vessels disclosed by the Rinkichō accident were expected to cost 40 million yen [38].

Nevertheless, no detailed open report of the Rinkichō accident was presented at the Imperial Diet. This fact strongly indicates that the Rinkichō accident was top secret information, which was not allowed to go beyond the Imperial Japanese Navy. What, then, were the facts? This question will be answered based on documents owned by Ryūtarō Shibuya who was an Engineering Vice Admiral of the Navy and was responsible for the turbine design of naval vessels at the time (these documents will be called the Shibuya archives hereafter).

---

15 The purpose of this treaty was to restrict the total displacement of all types of auxiliary warships other than battleships and battle cruisers, while that of the Washington naval disarmament treaty of 1922 was to restrict the total displacement of battleships and battle cruisers. This London treaty obliged the Imperial Japanese Navy to produce a new idea in hull design enabling heavy weapons to be installed within a small hull, which, however, proved to be achieved at the expense of the strength and stability of the hull, as the incident dramatically showed.

16 "When the Fourth Squadron was conducting maneuvers in the sea area to the east of Japan, they encountered a furious typhoon. They were attacked by very rare high waves. Two destroyers were tossed about tremendously. As a result, their bows were damaged. The damage to the engines and armament was considerable—two million yen for the ship and 800,000 ¥ for its armament, a total of 2.8 million yen" [37, p. 86].

17 The damage due to the collision between the cruisers *Abukuma* and *Kitakami* in terms of contemporary currency is based on the above-mentioned answer by the Navy minister Kiyotane Abo to a question by Viscount Tanetada Tachibana made on March 2, 1931 during the 59th Imperial Diet Session [37, p. 831].

10.6 The Hidden Accident and the Outbreak of War with the U.S. and Britain: How Did Japan Deal with the Problem?

The Shibuya archives are enormous, consisting of more than 4,000 materials on various subjects including casualties of the atomic bomb.[18] Even though we chose only the materials directly concerning the Rinkichō accident, it is impossible to present here a full analysis of all the details gleaned from these voluminous materials. Among these, this chapter focuses on the special examination committee established in January 1938. The purpose of the committee was as follows [39]:

> Problems were found with the turbines of Asashio-class destroyers…. It is necessary to work out remedial measures and study the design of the machinery involved and other related matters, so that such studies will help improvements. These research activities must be performed freely without any restrictions imposed by experience and practice in the past. The special examination committee has been established to fulfill this purpose.

Its organization was as follows [40]:

- General members who did not attend subcommittee meetings
  - Chair: Isoroku Yamamoto, Vice Admiral, Administrative Vice Minister of the Navy
  - Members: Rear Admiral Inoue, Director of the Bureau of Naval Affairs, the Ministry of the Navy and five other members
- First subcommittee for dealing with engine design and planning
  - Members: Leader: Shipbuilding Vice Admiral Fukuma, Director of the Fifth Department (including the turbine group), the Technical Headquarters of the Navy; and nine other members
- Second subcommittee for dealing with the maximum engine power and suitable load/volume
  - Members: Leader: Rear Admiral Mikawa, Director of the Second Department, the Naval General Staff; and eleven other members
- Third subcommittee for dealing with prior studies/experiments/systems and operations
  - Members: Leader: Rear Admiral Iwamura, Director of the General Affairs Department, the Technical Headquarters of the Navy; and ten other members

[18] When Japan was defeated in 1945, most military organizations were ordered to burn documents they had kept. Many documents of the Imperial Navy were burned before the General Headquarters of the U.S. Occupation Forces ordered the government to submit documents regarding the war. Ex-managers and ex-directors of the Imperial Japanese Navy then held meetings and decided to undertake a research project to collect, examine, and preserve technical documents to the extent possible. The Shibuya archives were the result of this project and came into the hands of Ryūtarō Shibuya. The description of the background of the Shibuya archives is based on Shibuya Bunko Chōsa Iinkai, Shibuya Bunko Mokuroku (Catalogue of the Shibuya Archives), March 1995, Commentary.

Table 10.5 Members of the special examination committee by section

Section	Number
Administrative vice minister of the navy	1
Bureau of naval affairs	8
Naval general staff	5
Technical headquarters of the navy	15
Naval staff college	3
Naval engineering school	1
Total	33

Note Calculated based on [40]

Ignoring duplication of members belonging to different subcommittees and arranging the net members by section, we obtain the following result (see Table 10.5).

The accident, as mentioned above, concerned the breakage of turbine blades. Tracing back the history of the development of the marine turbine in Japan since 1918 when the Navy began to adopt geared turbines, we find that various failures occurred with main turbines. When we classify these failures during the period from 1918 to October 1944 by location, failures involving turbine blades account for 60 % of the total (see Table 10.6).[19]

The Imperial Japanese Navy had thus had many problems with turbine blades for many years and accumulated experience in handling them. Accordingly, it is unsurprising that the special examination committee took the accident as merely a routine problem from the outset based upon such a long and rich experience. In fact, the special examination committee drew a conclusion made up of two points, both of which were in line with such accumulated experience. First, the accident was caused by insufficient blade strength. Second, turbine rotor vibration made the insufficient strength emerge as a problem [41]. On the basis of this conclusion, a plan was worked out to improve the design of the blades and rotors of the Kanpon type turbines for all naval vessels. It was decided to change the form of the blades so as to make their stress concentration lower to enhance their strength [42]. The improvement of 61 naval vessels' turbines was indicated as the first step, in accordance with the voluminous previous reports of 66 committee meetings held over a period of 10 months [43].

However, the blade breakage in the accident was significantly different from that in the past. In impulse turbines, for instance, blades in most cases were broken at the base where they were fixed to the turbine rotor. In contrast, one of the salient features of the Rinkichō accident was that the tip of the blade was broken off. The broken off part amounted to one third of the total length of the blade.[20] Figure 10.2 is a photograph showing the locus of the breakage.

[19] This classification assumes that if a problem at one location produces another problem at another location, the latter problem is not counted separately, but is considered part of the former.

[20] The breakage as described in the record written at that time is as follows: "Moving blades and the rivets on the tip of the 2nd and 3rd stages of the intermediate-pressure turbines were broken…. The break in every moving blade was located at 40–70 mm from the tip" [42].

Table 10.6 Turbine failures on naval vessels classified by location: 1918–1944

Location	Incidents	Percentage	Cumulative
Impulse blade and grommet	368	46.8	46.8
Reaction blade and binding strip	111	14.1	60.9
Reduction gear and claw coupling	80	10.2	71.1
Bearing and thrust bearing	66	8.4	79.5
Casing	46	5.9	85.7
Casing partition and nozzle	34	4.3	89.7
Blade wheel and spindle	22	2.8	92.5
Steam packing	20	2.5	95.0
Others	39	5.0	
Total	786	100.0	100.0

Source Based on [25, pp. 1–2]. Reaction blade means the blade of a traditional Parsons turbine (Cf., [25, p. 4].)

These facts indicated that the accident was significantly different from any previous routine problem. Yoshio Kubota, an Engineering Captain of the Navy who happened to be transferred to the Military Affairs Bureau in November 1938 when the special examination committee reported its conclusion, eventually noticed this point. It was not really permissible for a newcomer to the Military Affairs Bureau of the Navy to utter an objection to the latest conclusion of the special committee. In addition, six months before his transfer to the bureau, the Japanese government enacted the Wartime Mobilization Law on April 1, 1938 for the purpose of "controlling and organizing human and material resources most efficiently… in case of war" (Clause 1). Naval vessels came first in the specification of the law as "resources for wholesale mobilization" (Clause 2). Against this background of wartime mobilization, a naval engine failure caused by small tip fragments of the main standard engine was a very delicate matter for anyone to raise.[21] Despite the circumstances, Kubota strongly recommended that confirmation tests should be conducted again for naval vessels of the same type. He argued that if turbine rotor vibration was the true cause, then the failure would be repeatable when the engine was run continuously at the critical speed causing rotor vibration (nearly 6/10 to 10/10 of the full speed).[22]

The Navy finally decided to initiate continuous-run tests equivalent to ten-year runs on April 1, 1939. No failure occurred. This provided the Navy with the simplest practical rationale for cancelling the overall remedial measures for all naval vessels, which were expected to require huge amounts of extra money and

---

[21] Reference [44, p. 412]. The author was in charge of drafting the national mobilization plan at the Cabinet Planning Board (Kikaku In) in the prewar period. For the Navy, war preparation updates started from August 1940. See [45, pp. 93–94]. Sugiyama was the Chief of the General Staff at that time.

[22] Records of an interview with Yoshio Kubota made by the Seisan Gijutsu Kyōkai (Association for Production Technology) on March 19, 1955 [46].

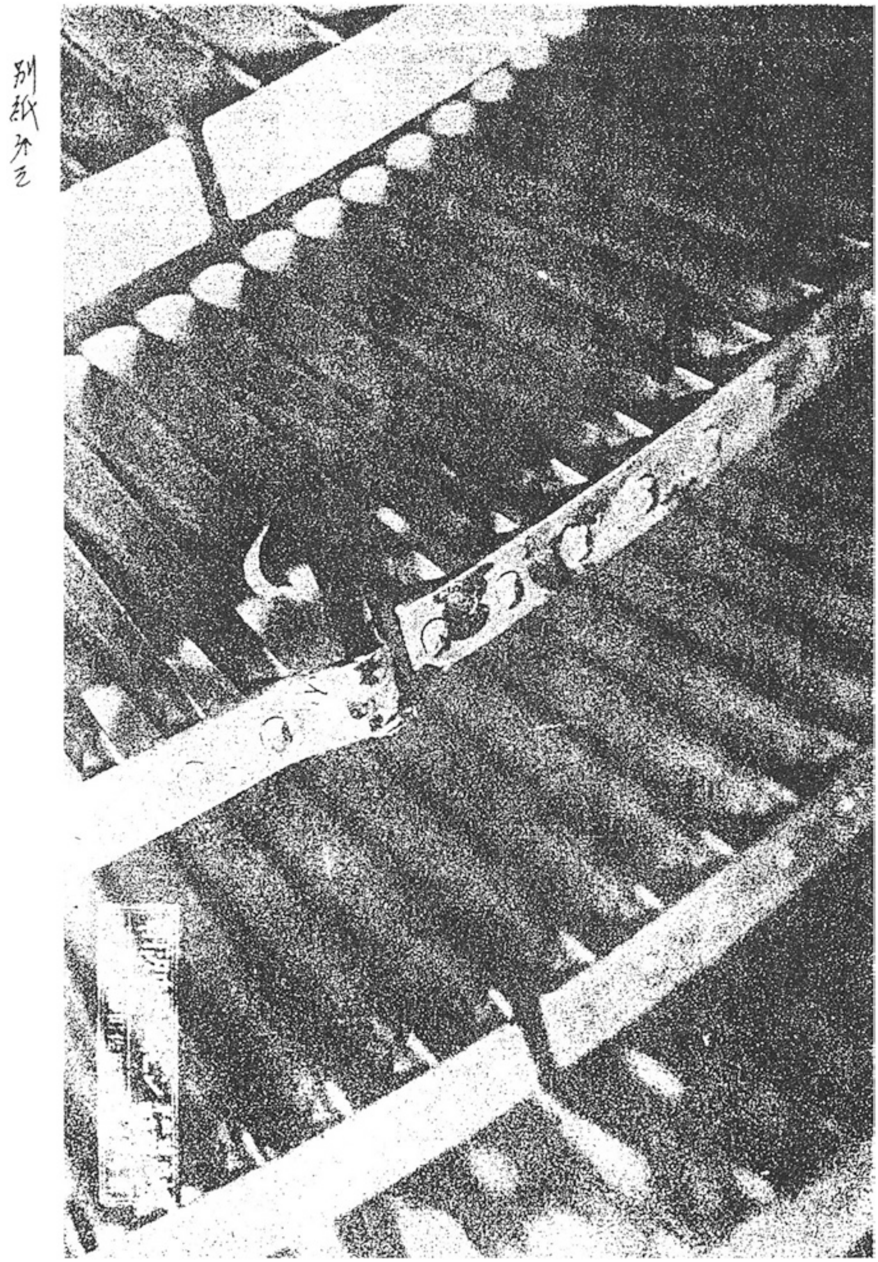


Fig. 10.2 Broken part of a blade in the Rinkichō accident (*Source* [42])

time.[23] An order was issued promptly to postpone the modification to the turbine blades and rotors of the Kanpon turbines for all naval vessels. At the same time, however, there was obviously an urgent need to consider the possibility of another cause and a study to identify the cause was restarted. The Maizuru Naval Dockyard conducted preliminary on-land tests and a more thorough one followed at the Hiro Naval Dockyard to confirm the conditions that would make the failure recur. However, the test was extremely difficult to carry out. There were two reasons for this. First, the complete test required the Dockyard to construct from scratch a full-scale experimental apparatus for a load test of vibration, which was only completed in December 1941, the month the war with the U.S. and Britain broke out. Second, the test turned out to be so large-scale, eventually extending to more than 35 main items, that it took far more time than expected. As a result, the schedule for identifying the cause, which was originally expected to be completed in November 1940, was extended to mid-1943.[24] Thus it is probable that all of Japan’s naval vessels had turbines which were imperfect for some unknown reason when the country went to war with the U.S. and Britain in 1941.

What, then, was the true cause for the accident? The true cause was binodal vibration. Previous efforts to avoid turbine vibration had been confined to one-node vibration at full speed since multiple-node vibration below full speed had been assumed to be hardly serious and unworthy of attention based on rule of thumb.[25] The final discovery of the true cause of the Rinkichō accident drastically changed the situation. It revealed that marine turbines are susceptible to a serious vibration problem below full speed. It was in April 1943 that this true cause was eventually identified by the final report of the special examination committee—almost one and half years after war broke out (see Fig. 10.3).[26]

Only three months before the submission of the report, a theoretical study made at the Hiro Naval Dockyard supported the conclusion that the true cause was binodal vibration.[27] The results of theoretical calculation, on-land confirmation testing, and the characteristics of the actual failure matched. The complete mechanism creating binodal vibration itself was still left for further studies. Even so,

---

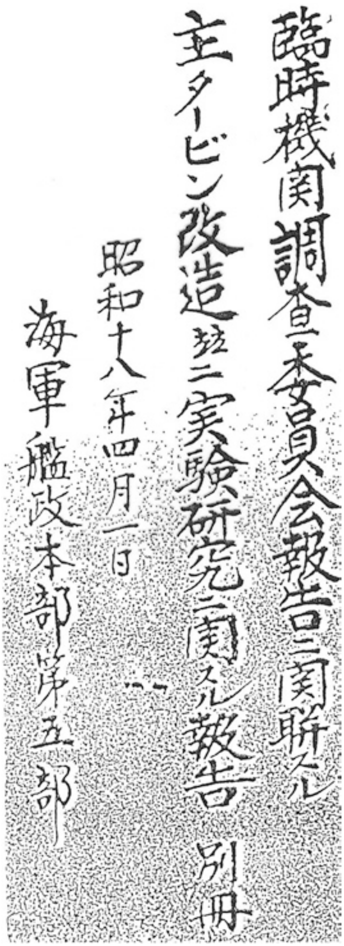
[23] These original remedial measures are kept in the Shibuya archives.

[24] The descriptions here are based on [47]. This is the final report of the special examination committee.

[25] In general, such was the standard of turbine design in the prewar period [48–50].

[26] According to this report, “Binodal vibration occurs when the product of the number of nozzles and the revolution of blades … equals the frequency of the blades at binodal vibration [47].” This means that a forced vibration caused by steam pulsation and a specific binodal frequency of blades resonate with each other, as a result of which binodal vibration occurs.

[27] It proved that even if uniform vertical and horizontal sections were assumed for the purpose of simplification, binodal vibration could produce the maximum stress at places less than three-fifths of the distance from the tip of a blade, which matched the place of the actual breakage in the failures [51]. Dr. Yasuo Takeda discovered this document on March 3, 1997, and it was added to the Shibuya archives.



臨時機関調査委員会報告ニ関聯スル
主タービン改造並ニ実験研究ニ関スル報告 別冊
昭和十八年四月一日
海軍艦政本部第五部

Fig. 10.3 The front page of the final report of the special examination committee (*Source* [47])

every result from the special examination committee that finally concluded in 1943 pointed to the same single cause: binodal vibration [52].[28]

Strictly in terms of the technology involved in the accident without hindsight, therefore, all the evidence suggests that the Japanese government went to war in

[28] Shigeru Mori, a contemporary Navy engineer who graduated from the Department of Physics of the Imperial University of Tokyo seems to have tried to construct a model to identify the mechanism, whose details are not available now See [53]. When we look at other circumstantial evidence such as the fact that the blade breakage was limited to a relatively small number of turbines of particular newly built destroyers, it was still plausible that the strength of particular blades had something to do with the failure. The Navy therefore revised its design directive to ensure an enormous increase (from 0.4 to 1.5 mm) in the thickness of turbine blades just after the submission of the final report of the committee in April 1943. The original design directive had been issued on May 1, 1931, the documents of which are collected in the Shibuya archives. In interpreting this circumstantial evidence, the author is indebted to Dr. Ryōichirō Araki for

haste in 1941 notwithstanding the fact that it had unaccounted for, highly intricate, and serious problems with the main engines of all its naval vessels. And that fact was kept secret by the military sector from other sectors involved in the military-industrial-university complex, not to speak of the general public. The rarity of breakdowns of naval vessels due to turbine troubles during the war is a completely different matter, one of hindsight. Thus, the Rinkichō accident strongly suggests that practical results alone (for example, rarity of breakdowns of naval vessels due to turbine troubles) during wartime, possibly in peacetime as well, do not prove the essential soundness of the development trajectory of technology, and that of the science-technology-society interface and national decision-making along the trajectory.

10.7 The Sociological Implications for the Fukushima Daiichi Accident: Beyond Success or Failure

The sociological implications of this Rinkichō accident that happened much earlier than the Fukushima Daiichi accident are closely related to the reasons why we can call it a little-known "structural disaster." One of the reasons is that it was much more serious and complex than expected and therefore kept secret from outsiders. This fact requires us to reconsider the development trajectory of technology beyond the simplistic dichotomy of success or failure throughout peacetime and wartime. According to a standard view of the history of technology in general, Japan proceeded to a self-reliant phase with the establishment of the Kanpon type turbine in the 1920s, after improvements made to deal with various problems and failure incidents. In short, a successful self-reliant phase followed subsequent to improvements after various failures.

And it has been assumed up to now that this trajectory enabled Japan to go to war in 1941. According to the description and analysis of the Rinkichō accident given above, however, the trajectory becomes much more complex than the conventional "success story" account suggests, since there was a serious but little known missing phase, one of "self-reliant failure," which the Navy was unable to completely solve by the outbreak of the war. Considering this in association with the similarity in terms of technological trajectory such that the reactors of the Fukushima Daiichi power station embody the turning point leading from licensed production to self-reliant production, there is the possibility that the Fukushima Daiichi accident was a "self-reliant failure" in the sense mentioned above.

Footnote (continued)

technical advice. Considering this circumstantial evidence together, there were possibly two closely associated aspects in the failure. One is a universal aspect leading to the detection of binodal vibration. The other is a more local aspect possibly due to the testing and quality control of the strength of the particular broken blades. Whatever weight may be given to each aspect in the description and analysis of the failure, however, as the date of the final report indicates, it was only after April 1943 that both aspects were finally noticed. By then, about one year and a half had already passed since the outbreak of the war with the U.S. and Britain in 1941.

There is another reason why we can describe the Rinkichō accident as a little-known "structural disaster." The reason is that the recognition of binodal turbine blade vibration as the true cause was beyond the knowledge of the usual turbine designer of the day. This type of problem is supposed to have been unrecognized until the postwar period. In the postwar period, avoiding turbine blade vibration caused by various resonances still provided one of the most critical topics for research on turbine design.[29] The Imperial Japanese Navy certainly managed, after the serious technological and organizational errors of the Rinkichō accident that was kept secret from outsiders, eventually to detect the universal true cause during the war. But its complete solution seems not to have been found after the detection of the true cause.[30]

In short, the problem was detected in the prewar period, but its final solution was left until after the war.[31] Far beyond the simplistic dichotomy of success or failure throughout peacetime and wartime, this hidden and little known "structural disaster", an important snapshot of a serious failure of Japan's self-reliant prewar technology, gives a significant confirmation of the functional disintegration of the network of the relationships linking the military and industrial sectors. That is to say, the incident enables us to look at a secret military problem-finding and investigation, and pioneering but partial diagnosis without a well-informed industrial problem-solving process. This was the end state of the military-industrial-university complex in the prewar period in which a pitfall was present within the success in technological development, from which the postwar industrial reconstruction in Japan started.

This will provide an important guideline for characterizing and understanding the Fukushima Daiichi accident beyond the simplistic dichotomy of success or failure. This is because the kind of fresh account exemplified here, which goes

[29] Cf., [54–59]. An article on the QE2's turbine reported that a similar failure occurred even in 1969. See [60].

[30] The same type of turbine blade breakage still occurred in the same class of destroyer more than one year after the final report of the special examination committee had been submitted. A destroyer of the same class was found to have had the same type of turbine blade breakage around "one-third of the blade from the tip" on July 21, 1944, an incident even less known than the Rinkichō accident [25, pp. 158–159]. Also see [61].

[31] Postwar industrial development, and the development of the steam turbine for commercial purposes, among other things, started from a careful re-examination of the binodal vibration problem left unsolved by the prewar/wartime military sector. For example, in 1953 Kawasaki Heavy Industries Ltd. invited three technical advisers to help develop an independent turbine technology for the future: Yoshitada Amari (ex-Engineering Rear Admiral of the Navy), and Kanji Toshima and Shōichi Yasugi (both ex-Engineering Captains of the Navy). They were all in the Technical Headquarters of the Imperial Japanese Navy at some stage of their prewar careers and were also concerned with the Rinkichō accident. And every detail of prewar turbine failures including the Rinkichō accident was inputted into an IBM computer and reanalyzed, from which the company obtained an exact normal tolerance for the strength of turbine blades and a design to avoid binodal vibration. Based on [62] and a letter from Yasuo Takeda, Kawasaki Heavy Industries Ltd. to Kanji Toshima, IHI. (n.d.). For a detailed description and analysis of the Rinkichō accident, see [24, pp. 159–172].

beyond a dichotomous narration, has tended to be unduly neglected up to now in the sociology of science and technology and particularly in relation to the sociological studies on extreme events such as the Fukushima Daiichi accident. As a matter of fact, the Rinkichō accident that occurred after a long history of successful technological development reminds us of its structural similarity to the Fukushima Daiichi accident that happened after a long successful operation of nuclear reactors closely associated with the myth of safety.

Another sociological implication that could be obtained from this hidden accident pertains to the social context of organizational errors involved in "structural disaster." As mentioned earlier, the social context of the Rinkichō accident is the wartime mobilization of science and technology, which was authorized by the Wartime Mobilization Law in 1938 and the Research Mobilization Ordinance in the next year. This formal legal foundation gave rise to one of the salient features of the wartime mobilization of science and technology, namely the structural interdependence of the military-industrial-university complex under the control of the military sector. The military sector controlled the overall mobilization, in which the industrial sector and universities had to obey orders given by the military. This was associated with an extremely secretive attitude of the military toward outsiders. According to Hidetsugu Yagi who invented the pioneering Yagi antenna, a crucial component technology of radars, and in 1944 became the president of the Board of Technology, the central governmental authority specially set up for the wartime mobilization of science and technology, the military "treated civilian scientists as if they were foreigners."[32]

Thus, even at the central governmental authority specially set up to integrate every effort for the wartime mobilization of science and technology, cooperation, not to speak of coordination, with the military sector was very limited and the military-industrial-university complex began to lose its overall integration. Particularly in terms of the relationship between the military and industrial sectors, functional disintegration went further. What is important here is the fact that this functional disintegration of the network of relationships linking the military and industrial sectors was taking place just at the time the strong structural integration of the complex was formally being reinforced by the Wartime Mobilization Law and the Research Mobilization Ordinance.

And this coupling of structural integration and functional disintegration during wartime mobilization provides a suitable background for redefining success and failure not only in prewar Japan's context but in the current context of the Fukushima Daiichi accident. The reason for this is that the social context of organizational errors involved in the Rinkichō accident provides us with an important insight such that if the Fukushima Daiichi accident is a "structural disaster" it could have some characteristics similar to the coupling of structural integration and functional disintegration. For example, functional disintegration of the network of relationships linking the government, TEPCO officials, and the relevant reactor designers of makers might

[32] The statements by Yagi are based on [63]. These are Yagi's words on September 11, 1945, when interrogated by General Headquarters of U.S. Army Forces, Pacific Scientific and Technical Advisory Section.

be taking place just at the time the strong structural integration of the government-industrial-university complex was formally reinforced by the seemingly well-organized ordinances and laws revolving around the "double-check" system within a single ministry in the past and that between two ministries now, between METI and the Ministry of the Environment, ministry-bounded in either case.

10.8 Conclusion: Prospects for the Future

From the perspective of "structural disaster", there are two different kinds of similarities between the Rinkichō accident and the Fukushima Daiichi accident: one relating to technological trajectory, the other to the social context of organizational errors.

First, regarding similarity between the two accidents in terms of technological trajectory, both accidents took place in the stage of domestic or almost entirely domestic production of a technology once produced through license contracts after a successful operation of domestically produced technologies extending over 10–30 years. In that particular sense, both accidents could be categorized in the "self-reliant failure" type.

Second, there could be similarity between the two accidents in terms of the social context of organizational errors. This is because the coupling of structural integration and functional disintegration observed in the Rinkichō accident could similarly reside in the Fukushima Daiichi accident, particularly with respect to the relationships between the governmental and industrial sectors.

Of course, there are differences between the two accidents. Among other things, the difference in the way organizational errors came to be detected and corrected is noteworthy. In the Rinkichō accident, the conclusion once submitted by the final report of the special examination committee and authorized by the organization in question was dynamically cancelled by carefully observed facts regardless of the rank in the organization of those who pointed out the facts and the past experience accumulated in the organization. Such a dynamic reconsideration of alternative possibilities that upset the face-saving procedure within a specific organization triggered the restart of the examination leading to a drastically different conclusion. In the Fukushima Daiichi accident, in contrast, up until now there has been no sign showing the working of this kind of dynamic correction of organizational errors. At least looking at inside stories of TEPCO, Nuclear and Industrial Safety Agency (NISA), and other governmental bodies that have been disclosed one after another, one might rather well suspect the working of mutual "cover-ups" within and/or between those organizations in question, though the possibility of the dynamic correction of organizational errors might still be left open. This difference is noteworthy because, even with the working of such a dynamic correction of organizational errors, reconsideration of alternative possibilities, and restarting of development, the timing of the realization of the true cause of the Rinkichō accident was too late for Japan to check the soundness of national decision-making before going to war in haste in 1941.

In sum, putting together the similarity between the Rinkichō accident and the Fukushima Daiichi accident as “structural disaster” and their difference as to whether the dynamic correction of organizational errors and the reconsideration of alternative possibilities could work, there remains the possibility that the causes of “structural disaster” embedded in the Fukushima Daiichi accident will continue in a path-dependent manner. In such a case, the science-technology-society interface surrounding the Fukushima Daiichi accident will probably be unable to tolerate another impact that could be given by serious and unexpected events such as a second huge earthquake and tsunami and/or the difficulty of decontamination within some of the reactors in question and their abrupt uncontrollability.

One of the most important lessons from understanding the Fukushima Daiichi accident as “structural disaster” based on scrutinizing the hidden one that happened much earlier is how to avoid the worst state of this kind. That is to say, the seemingly structurally robust but functionally disintegrated science-technology-society interface due to secrecy should be changed. By the same token, while various communication activities to facilitate links between science, technology, and society had been carried out with public funds as represented in café scientifique before the Fukushima Daiichi accident, it turns out that there had been only one café scientifique on anything nuclear (held on July 24, 2010) out of 253 carried out in the Tohoku district including Fukushima prefecture. And yet the topic taken up there had nothing to do with any kind of risk from nuclear power plants, not to speak of extreme events such as the Fukushima Daiichi accident.[33] This implies that various activities supposed to facilitate well-balanced links between science, technology, and society in reality did nothing in advance about the communication of the negative aspect of nuclear power plants and therefore played no role in early warning against extreme events such as the Fukushima Daiichi accident.

As long as this kind of functional disintegration of the science-technology-society interface continues to exist and operate behind the façade of structural integration, such a state can lead to a similar dangerous weakness in quite a different and larger-scale social context. The possibility of functional disintegration through structural interdependence accompanied with secrecy and the suppression of negative information under the name of communication activities could constitute one of the important symptoms of “structural disaster.” This state should be changed by the will of the people who are suffering from the Fukushima Daiichi accident for the purpose of instituting a significant structural remedy, the remedy which is far beyond counter measures that only temporarily patch over individual troubles coming into sight at the moment and serve to save face of responsible agents concerned.

[33] What is mentioned here is confirmed on November 18, 2011 through the following portal website on café scientifique in Japan: http://cafesci-portal.seesaa.net/.

References

1. TMM, No. 1119, June 25 (2011) sent by No Nukes Plaza Tokyo.
2. Matsumoto M (2002) Chi no shippai to shakai (The structural failure of the science-technology-society interface). Iwanami Publishing Co., Tokyo, pp 25-27
3. Wynne B (1996) Misunderstood misunderstandings: social identities and public uptake of science. In Irwin A, Wynne B (eds), Misunderstanding science?: The public reconstruction of science and technology. Cambridge University Press, Cambridge, pp 19-46
4. Collins H (2011) The third wave of science studies: the development and politics. Japanese Journal for Science, Technology & Society 20: 81-106
5. Perrow C (1984) Normal accidents: Living with high risk technologies. Basic Books, New York
6. Perrow C (1999) Normal accidents: Living with high risk technologies: With a new afterword and a postscript on the Y2K problem. Princeton University Press, Princeton
7. Walker JS (2004) Three Mile Island: A nuclear crisis in historical perspective. The University of California Press, Berkeley
8. Matsumoto M (2005) The uncertain but crucial relationship between a 'new energy' technology and global environmental problems. Social Studies of Science 35(4): 623-651
9. Latour B (1996) Aramis, ou L'amour des techniques. la Décourverte, Paris. English edition: Latour B (1996) Aramis or the Love of Technology (trans: Porter C). Harvard University Press, Cambridge, Massachusetts
10. Perrow C (2007) The next catastrophe. Princeton University Press, Princeton
11. Matsumoto M (2012) Kozosai (The structural disaster). Iwanami Publishing Co., Tokyo
12. Atomic Energy Society of Japan (2009) http://www.aesj.or.jp/awards/2008/2008-119-120.pdf. Ascertained on 21 Mar 2013
13. Tokyo Electric Power Company (2014) http://www.tepco.co.jp/nu/f1-np/intro/outline/outline-j.html. Ascertained on June 9 2014
14. Vaughan D (1996) The Challenger launch decision: Risky technology, culture, and deviance at NASA. The University of Chicago Press, Chicago
15. MacFarlane A (2003) Underlying Yucca mountain: The interplay of geology and policy in nuclear waste disposal. Social Studies of Science 33(5): 783-807
16. Eden L (2004) Whole world on fire: Organizations, knowledge, and nuclear weapons devastation. Cornell University Press, Ithaca
17. Jobin P (2013) Radiation protection after 3.11: Conflicts of interpretation and challenges to current standards based on the experience of nuclear plant workers. Paper presented at Forum on the 2011 Fukushima/East Japan Disaster, 13 May, 2013, Berkeley.
18. Constant II E (1980) The origins of the turbojet revolution. The Johns Hopkins University Press, Baltimore
19. Parsons CA (1984) Improvements in mechanism for propelling and controlling steam vessels, Patent Record No.394 A.D.1894 (Kept by Tyne & Wear Archives Service in Newcastle upon Tyne)
20. Scaife WG (1991) Charles Parsons' experiments with rocket torpedoes: The precursors of the steam turbine. Transactions of the Newcomen Society for the Study of the History of Engineering and Technology 60: 17-29
21. Matsumoto M (2013) Structural disaster long before Fukushima: A hidden accident. Development & Society 42(2): 165-190
22. Legett D (2011) Spectacles and witnessing: constructing readings of Charles Parsons's marine turbine. Technology and Culture 52(2): 287-309
23. Somerscale EFC (1992) The vertical Curtis steam turbine, Transactions of the Newcomen Society for the Study of the History of Engineering and Technology, 63: 1-52
24. Matsumoto M (2006) Technology gatekeepers for war and peace. Palgrave Macmillan, Basingstoke
25. Seisan Gijutsu Kyōkai (ed) (1954) Kyū kaigun kantei jōki tābin koshō kiroku (Record of the problems and failures of naval turbines of the Imperial Japanese Navy) Seisan Gijutsu Kyō kai (for private distribution), Tokyo

26. Shibuya R (1970) Kyū kaigun gijutsu shiryō (Technical materials of the Imperial Japanese Navy). Association for Production Technologies (for private distribution), Tokyo, Vol. 1, Chapter 4
27. Murata S (n.d.) *Asashio* Gata Shu Tābin no Jiko (An accident of the main turbines of the *Asashio*-class), Manuscript, p 6
28. Hakuyō Kikan Gakkai Hakuyō Kikan Chōsa Kenkyū Iinkai (The Research Committee of the Marine Engineering Society of Japan) (ed) (n.d.) Nippon hakuyō kikan shi Jōki tābin hen Sōkō (An unpublished manuscript of the history of marine engineering in Japan: The steam turbine), Appended tables
29. The Shipbuilding Society of Japan (ed) (1977) Shōwa zōsen shi (The history of shipbuilding in the Showa period), Hara Shobō, Tokyo
30. Samuels RJ (1994) Rich nation, strong army: National security and technological transformation of Japan. Cornell University Press, Ithaca
31. Smith C, & Wise MN (1989) Energy and empire: A biographical study of Lord Kelvin. Cambridge University Press, Cambridge
32. Leslie SW (1993) The cold war and American science: The military-industrial-academic complex at MIT and Stanford. Columbia University Press, New York
33. Sendō M (ed) (1952) Zōsen gijutsu no zenbō (A conspectus of warship construction technology)
34. Itō M (1956) Dai kaigun o omou (On the Imperial Japanese Navy)
35. The War History Unit of the National Defense College of the Defense Agency (ed) (1969) Kaigun gunsenbi (The Military Equipment of the Navy). Tokyo
36. The Institute for the Compilation of Historical Records relating to the Imperial Japanese Navy (1981) Kaigun (The Navy)
37. Kaigun Daijin Kanbō Rinji Chōsa Ka (Temporary Research Section, the Minister of the Imperial Japanese Navy's Secretariat) (ed) Teikoku gikai kaigun kankei giji sokki roku (Minutes of Imperial Diet sessions regarding Navy-related subjects), Bekkan 1, 2. Reprinted edition: (1984) Vol. 3, Part 1. Hara Shobō, Tokyo
38. Shibuya R (n.d.) Jūgo zuihitsu (Essays). sono 4
39. The Minister of the Navy's Secretariat (1938) Military secret No. 266. Issued on January 19, 1938
40. Rinkichō Report (1938) Top secret No. 35, Appended sheets. Issued on November 2, 1938
41. Rinkichō Report (1938) Top secret No. 35. Issued on November 2, 1938
42. Rinkichō Report (1938) Top secret No. 1. Issued on February 18, 1938
43. Rinkichō Report (1938) Top secret No. 1. Issued on February 18, 1938 through Top secret No. 27. Issued on October 13, 1938
44. Ishikawa J (ed) (1982) Kokka sōdōin shi (The history of national mobilization), Compiled materials, Vol. 3. Kokka Sōdōin Shi Kankō Kai, Fujisawa
45. Sanbō Honbu (ed), Sugiyama memo (Sugiyama memorandum). Reprinted: (1967) Vol. 1. Hara Shobō, Tokyo
46. Kubota Y (1981) 85 nen no kaisō (Reminiscences of 85 years). for private distribution, Tokyo, pp 50-51
47. Kaigun Kansei Honbu Dai 5 Bu (1943) Rinji Kikan Chōsa Iinkai Hōkoku ni kansuru Shu Tābin Kaizō narabini Jikken Kenkyū ni kansuru Hōkoku (Report on the Remedy and the Experimental Research of the Main Turbines in connection with the Rinkichō Report), Bessatsu. April 1, (1943)
48. Sezawa K (1932) Vibrations of a group of turbine blades. Zosen Kyōkai Kaihō 50: 197-206.
49. Pigott SJ (1937) Some special features of the S.S.Queen Mary. Engineering 143: 387-390
50. (1940) Turbine-blade fatigue testing. Mechanical Engineering 62(12): 919-921
51. Engineering Lieutenant Nozaki (1943) Tābin yoku no shindō ni kansuru kenkyū (A theoretical study on turbine blade vibration). January 15, 1943
52. Ono K (1943) Tābin yoku no kyōsei shindō ni kansuru kinji keisan (An approximate calculation on the forced vibration of turbine blades. Engine Laboratory, Department of Sciences, Naval Technical Research Institute, August 1943

53. Mori S (1969) Waga seishun (My youth). Shizuoka Newspaper, August 29, August 30, September 1, 1969
54. Trumpler Jr. WE, Owens HM (1955) Turbine-blade vibration and strength. Transactions of the American Society of the Mechanical Engineers: 337-341
55. Andrews F, & Duncan JP (1956) Turbine blade vibration: Method of measurement and equipment developed by Brush. Engineering: 202-208, August 17, 1956
56. Luck GA, Kell BC (1956) Measuring turbine blade vibrations: Development of barium titanate transducers. Engineering 31: 271-273
57. Leist K (1957) An experimental arrangement for the measurement of the pressure distribution on high-speed rotating blade rows. Transactions of the American Society of the Mechanical Engineers: 617-626
58. Wahl AM (1957) Stress distribution in rotating disks subjected to creep at elevated temperature. Journal of Applied Mechanics: 299-305
59. Visser NJ (1960) Turbine blade vibration. VMF Review 2: 61-62
60. Report on *QE2* turbines. Shipbuilding and Machinery Review, March 13, 1969: 24-25
61. Matsumoto M (1999) A hidden pitfall in the path of prewar Japanese military technology. Transactions of the Newcomen Society 71(2): 305-325
62. Takeda Y (n.d.) Kawajū wa Kanpon Shiki Tābin no Point o Dōshite Toraetaka (How did the Kawasaki Heavy Industries Ltd. assimilate the points of the Kanpon Type Turbine?); Kawasaki Tābin Sekkei Shiryō (Kawasaki Turbine Design Materials), Dai 2 Bu (October, 1955)
63. Report on Scientific Intelligence Survey in Japan, 1945, Vol. III (GHQ/SCAP Records Box No. 8354 ESS (1)-00727), Appendix 3-A-1